

603.14.3**603.14.3-PAY ITEMS:**

ITEM	DESCRIPTION	UNIT
603016-*	"size" PRESTRESSED CONCRETE BOX BEAM	LINEAR FEET (METER)
603017-*	"size" PRESTRESSED CONCRETE PLANK BEAM	LINEAR FEET (METER)
603018-*	"size" PRESTRESSED CONCRETE I BEAM	LINEAR FEET (METER)
603019-*	"size" PRESTRESSED CONCRETE BULB T BEAM	LINEAR FEET (METER)
603020-*	"size" PRESTRESSED CONCRETE DECK PANEL	LINEAR FEET (METER)
603021-*	"size" PRECAST CONCRETE DECK PANEL	LINEAR FEET (METER)
603027-*	PRECAST REINFORCED CONCRETE THREE-SIDED STRUCTURE	LINEAR FEET (METER)
603028-*	PRECAST REINFORCED CONCRETE WINGWALL	LINEAR FEET (METER)
603029-*	PRECAST REINFORCED CONCRETE HEADWALL	SQUARE FEET (METER)

* Sequence Number

SECTION 604

PIPE CULVERTS

604.1-DESCRIPTION:

This work shall consist of the construction or reconstruction of pipe culverts, referred to as "conduit", in accordance with these Specifications and in reasonably close conformity with the lines, grades, dimensions, and locations shown on the plans or established by the Engineer.

604.2-MATERIALS:

Materials shall meet the requirement specified in the following Subsections of Division 700:

<u>MATERIAL</u>	<u>SUBSECTION</u>
Metallic Coated Corrugated Steel Pipe or Pipe Arch.....	713.2
Corrugated Stainless Steel Pipe.....	713.7
Bituminous Coated Corrugated Steel Pipe or Pipe Arch.....	713.3
Precoated, Metallic Coated steel Pipe.....	713.23
Bituminous Coated and Paved Invert Corrugated Steel Pipe or Pipe arch.....	713.3
Precoated and Paved Invert Metallic Coated Steel Pipe or Pipe Arch.....	713.23
Full Bituminous Coated and Full Paved Corrugated Steel Pipe.....	713.4
Precoated and Full Paved Metallic Coated Steel Pipe.....	713.23
Fiber Bonded Full Bituminous Coated Corrugated Steel Pipe	713.5
Fiber Bonded Full Bituminous Coated and Paved Invert	

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Corrugated Steel Pipe.....	713.5
End Section for Corrugated Steel Pipe or Pipe Arch.....	713.20
Precoated, Metallic Coated Steel Pipe Arch.....	713.23
Fiber Bonded Full Bituminous Coated and Full Paved	
Corrugated Steel Pipe.....	713.6
Fiber Bonded Full Bituminous Coated Corrugated Steel Pipe	
Arch.....	713.5
Fiber Bonded Full Bituminous Coated and Paved Invert	
Corrugated Steel Pipe Arch.....	713.5
Structural Plate Pipe or Pipe Arch.....	713.8
Bituminous Coated Structural Plate Pipe or Pipe Arch.....	713.9
Structural Plate Arch.....	713.8
Bituminous Coated Structural Plate Arch.....	713.9
Stainless Steel Structural Plate Pipe.....	713.10
Corrugated Aluminum Alloy Pipe or Pipe Arch.....	713.14
Bituminous Coated and Paved Invert Corrugated Aluminum	
Alloy Pipe or Pipe Arch.....	713.15
End Section for Corrugated Aluminum Alloy Pipe or Pipe	
Arch.....	713.21
Aluminum Alloy Structural Plate Pipe or Pipe Arch.....	713.18
Aluminum Alloy Structural Plate Arch.....	713.18
Non-Reinforced Concrete Sewer Pipe.....	714.1
Reinforced Concrete Pipe.....	714.2
Reinforced Concrete End Section for Round Concrete Pipe.....	714.18
Reinforced Concrete Pipe Arch.....	714.3
Reinforced Concrete End Section for Arch-Shaped Concrete	
Pipe.....	714.18
Reinforced Concrete Elliptical Pipe.....	714.4
Reinforced Concrete End Section for Elliptical Concrete	
Pipe.....	714.18
Clay-Lined Reinforced Concrete Pipe.....	714.9
Clay Pipe, Standard Strength.....	714.10
Clay Pipe, Extra Strength.....	714.10
Bituminized Fiber Pipe (non-perforated).....	714.14
Corrugated Polyethylene (PE) Pipe.....	714.19
Acrylonitrile-Butadiene-styrene (ABS) Pipe.....	714.21
Polyvinyl Chloride (PVC) Pipe.....	714.22
Reinforced Plastic Mortar (RPMP) Pipe.....	714.17
Fiberglass Reinforced (FRP) Pipe.....	714.16
Asphalt Cement for Field Paving Structural Plate Pipe	
and Pipe Arches.....	705.5, Grade 40-50
Vitrified Clay Pipe Joints.....	708.5
Hot Pour Mineral Filled Joint Sealer.....	708.6
Flexible Watertight Gaskets for Circular Concrete Pipe.....	708.7
Joint Mortar.....	708.8
Bituminous Plastic Cement.....	708.9

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Granular Material for Culvert Bedding.....	716.1.1.2
Controlled Low Strength Material.....	219
Crushed Aggregate Backfill.....	704.6, Class I
Aluminum Coated Corrugated Steel Pipe and Pipe Arch.....	713.24
Precast Reinforced Concrete Box Culverts	714.23
Safety Slope End Sections.....	713.20
Fine Aggregate.....	*

*Fine Aggregate shall consist of crushed or uncrushed mineral aggregate which has 100 percent passing the $\frac{3}{8}$ in. (9.5 mm) sieve.

When the locations of manufacturing plants allow, the plants may be inspected periodically for compliance with specified manufacturing methods, and material samples may be obtained for laboratory testing for compliance with material quality requirements. This may be the basis for quality acceptance of manufactured lots.

All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

All references to "corrugated steel pipe" are considered applicable to uncoated pipe and the various combinations of coated pipes (bituminous coated, fiber bonded, precoated, etc.) and paving classes (paved invert, full paved, etc.) for which the base metal conforms to AASHTO M 218 or AASHTO M 274.

The sheet thickness for corrugated steel pipe and corrugated aluminum alloy pipe shall be as designated on the Plans.

Corrugated metal pipe of 2-2/3 by $\frac{1}{2}$ inches (68 mm by 13 mm) corrugation shall be furnished unless otherwise specified.

Corrugated steel pipe and pipe arch with 2-2/3" x $\frac{1}{2}$ ", 3" x 1", and 5" x 1" (68 mm by 13 mm, 75 x 25 mm and 125mm x 25mm) corrugations shall be helically fabricated, except for fiber bonded pipe which may be fabricated with annular corrugated of 2-2/3" x $\frac{1}{2}$ " and 3" x 1" (68 mm x 13 mm and 75 mm x 25 mm). Corrugated aluminum alloy pipe with 2-2/3" x $\frac{1}{2}$ ", 3" x 1", and 6" x 1" (68 mm x 13 mm, 75 mm x 25 mm, 75 mm x 25 mm, and 150 mm x 25 mm) corrugations and corrugated aluminum alloy pipe arch with 2-2/3" x $\frac{1}{2}$ " (68 mm x 13 mm) corrugations shall be helically fabricated. Where 5" x 1" (125 mm x 25 mm) corrugations are specified for corrugated steel pipe and pipe arch, 3" x 1" (75 mm x 25) corrugations may be substituted.

604.2.1-QUALITY CONTROL TESTING:

Quality control of the fine aggregate, granular material and crushed aggregate backfill is the responsibility of the Contractor as specified in 106.1.

Acceptance for gradation will be on the basis of the Contractor's written certification that all such material used for this conforms to the specified requirements. The certification is to include the results of testing from samples obtained at a minimum frequency of one sample per one-half day of aggregate production or stockpiling.

CONSTRUCTION METHODS

604.3-GENERAL:

Subject to the provisions prescribed, the flow line of a conduit may be altered from that shown on the plans. If a firm conduit foundation is not encountered at the specified elevation, the unsatisfactory material shall be replaced with suitable material to a depth directed by the Engineer.

Galvanized steel pipe or bands shall not come in contact with aluminized steel pipe or bands.

The diameter of conduit, as used in this Section, is the largest dimension, horizontal or vertical.

604.4-TRENCH EXCAVATION:

604.4.1-Conduits 18 Inches (450 mm) Through 54 Inches (1400 mm):

In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a minimum distance of six diameters on each side of the conduit and to a height of 2 feet (600 mm) over the top of the conduit or to the surface of the completed embankment if less than 2 feet (600 mm) above the top of the conduit. The width of the trench, in either cut or fill sections, shall not be less than the outside diameter of the conduit or encasement plus 18 inches (450 mm) on each side of the conduit measured to the face of the trench or to the sheeting when used.

604.4.2-Conduits 60 Inches (1500 mm) Through 108 Inches (2700 mm):

In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a distance of six diameters on each side of the conduit and to a minimum height of 25 percent of the vertical dimension of the conduit. The width of the trench shall not be less than the outside horizontal diameter of the conduit plus one diameter on each side of the conduit. When using a Controlled low strength material the width of the trench shall not be less than the outside horizontal diameter of the conduit plus one half diameter on each side of the conduit.

In rock or shale cut section, the width of the trench shall not be greater than required to obtain the backfill compaction specified. Soil cut trenches shall be treated as complete or partial fill sections. For rigid pipe, the width of the trench shall not be less than the outside horizontal diameter of the conduit plus 24 inches (600 mm) on each side of the conduit.

604.4.3-Conduit Greater Than 108 Inches (2700 mm): In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a distance of six diameters on each side of the conduit and to a minimum height of 25 percent of the vertical dimension of the conduit.

Installation of the conduit shall be as detailed in the plans, including the type and amount of backfill and bedding.

For flexible conduit, the Contractor shall submit shop drawings detailing all erection procedures including anticipated movements during backfilling

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operations. Backfill operations shall also be detailed to show lift thicknesses, sequence of lifts and shape of the conduit during these operations.

The Contractor shall submit a plan of field control for the installation insuring the conduit is erected in accordance with the shop and erection drawings.

604.4.4-Structural Plate Arches: Excavation for the foundations of structural plate arches shall be as for box culverts and structures and in accordance with [212.3](#).

604.5-BEDDING

604.5.1-General: The conduit bedding shall conform to one of the classes described below as specified. When no bedding class is specified, the requirements for Class B bedding shall apply.

When a firm foundation is not found at grade due to the presence of foreign material or trash, or due to the presence of moisture eight percent in excess of optimum, the unsatisfactory material shall be removed for the width of the conduit plus 18 inches (450 mm) on each side and replaced with granular material.

604.5.2-Class A Bedding: Class A bedding shall consist of a continuous concrete cradle conforming to the plan details.

604.5.3-Class B Bedding: Class B bedding shall consist of bedding the conduit in an earth foundation of uniform density, carefully shaped by means of a template to fit the lower conduit exterior for at least 15 percent of the overall height of the conduit. Exception is made in the case of structural plate pipe where the length of the bedding arc need not exceed the width of the bottom plate. However, if the structural plate pipe is first assembled and then placed in the trench, the 15 percent embedment specified above shall apply. Recesses shall be made in the trench bottom to accommodate the bell when bell and spigot type conduit is used. Fine aggregate shall be used to level the foundation. When rock is encountered, it shall be removed and replaced with specified material having a thickness under the conduit of 2 in. per ft. (40 mm per m) height of fill over the top of the conduit, with a minimum thickness of 12 inches (300 mm) and a maximum thickness of 24 inches (600 mm).

604.5.4-Class C Bedding: Class C bedding shall be in accordance with the details shown on the Plans. Recesses shall be made in the trench bottom to accommodate the bell when bell and spigot type conduit is used.

604.6-LAYING AND JOINING:

604.6.1-Rigid and Flexible Conduits: The conduit placing, unless the Contractor is otherwise directed, shall begin at the downstream end of the conduit. The lower segment of the conduit shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of rigid conduits and

outside circumferential laps of corrugated steel pipe and corrugated aluminum alloy pipe conduits shall be placed facing upstream.

Paved or partially lined conduit shall be laid so that the longitudinal centerline of the paved segment coincides with the flow line.

Rigid conduits may be of either bell and spigot or tongue and groove design, unless one type is specified. The method of joining conduit sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.

Joints for rigid conduits shall be made with (1) portland cement mortar or grout, (2) flexible watertight gaskets, (3) bituminous plastic cement, (4) oakum and mortar, (5) oakum and joint compound, (6) vitrified clay pipe joints, (7) hot pour mineral filler joint sealer, or by a combination of these types.

When mortar joints are used for tongue and groove and bell and spigot conduit, they shall be made by plastering up to the quarter point the joint mortar before the succeeding joint is placed. Thickness of mortar shall be sufficient to maintain proper invert grade. The accessible outer joint shall then be filled with an excess of mortar to form a bead around the outside of the conduit and finished smooth on the inside. For grouted joints, molds or runners shall be used to retain the poured grout. When portland cement mixtures are used, the completed joints shall be protected against rapid drying by suitable covering material. Where oakum is used, the joint shall be caulked with oakum and then sealed with the joint compound. When rubber or plastic gaskets are used, they shall be installed to form a flexible watertight seal.

Flexible conduits shall be joined by couplings in accordance with manufacturers recommendations, and the pipe shall be fastened to preserve the alignment and prevent the separation of sections.

Conduit shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged shall be removed and relaid or replaced.

604.6.2-Structural Plate Pipe and Pipe Arches: The bottom plates of structural plate pipe and pipe arches shall be assembled in a line, placing each section in the order recommended by the manufacturer. Side and top plates shall then be placed in the order recommended by the manufacturer. Bolts shall be placed in the location and number as recommended by the manufacturer. Plates shall lap each other the width of one corrugation, and bolts shall be inserted and nuts hand tightened as each plate is placed. Drift pins may be used to facilitate matching holes. When all the plates are in position and all bolts placed, all bolts shall be gone over a second time to insure proper tightening. Steel bolts shall be torqued during installation to a minimum of 100 ft. - lbs. (135 newton meters), and a maximum of 300 ft. - lbs. (400 newton meters) Aluminum bolts shall be torqued during installation to a minimum of 100 ft. - lbs. (135 newton meters), and a maximum of 150 ft. - lbs. (200 newton meters) For power driven tools, the hold-on period may vary from 2 to 5 seconds. Bolts shall be of sufficient length to provide for a full nut. When the structure is bituminous coated, all bolts and nuts shall be coated inside and outside of the

structure, after completion of bolt tightening, with bituminous material conforming to the requirements of [713.3](#).

604.6.3-Structural Plate Arches: Plate arches shall be set on footings as shown on the Plans. Beginning at the upstream end, the first side plates shall be set on the base angles. Then the remaining side plates and the top plates of the arch shall be bolted into place using only enough bolts to hold them without tightening securely. Drift pins may be used to assist in matching bolt holes. Temporary props may be used to hold plates in place until connections are made. After the plates comprising the first arch have been assembled, the next set shall be placed in the same manner, finishing each set of side plates with a top plate before placing in the same manner, finishing each set of side plates with a top plate before placing the next set of side plates. New plates shall be lapped one corrugation on the outside of the preceding plates. When all the plates are in position, the remaining bolts shall be inserted and all nuts firmly tightened. Steel bolts shall be torqued during installation to a minimum of 100 ft. - lbs. (135 newton meters), and a maximum of 300 ft. - lbs. (400 newton meters) Aluminum bolts shall be torqued during installation to a minimum of 100 ft. - lbs. (135 newton meters), and a maximum of 150 ft. - lbs. (200 newton meters) For power driven tools, the hold-on period may vary from 2 to 5 seconds. Bolts shall be of sufficient length to provide for a full nut. When the structure is bituminous coated, all bolts and nuts shall be coated inside and outside of the structure, after completion of bolt tightening, with bituminous material conforming to the requirements of [713.3](#).

604.7-ELONGATION:

When specified on the plans, factory elongation of flexible pipe shall be not less than four percent and not more than six percent vertically. Elongation shall be maintained during shipping, storing and handling.

604.8-BACKFILLING:

Backfill material shall be suitable random material free from particles larger than 3 inches (75 mm), crushed aggregate backfill, or controlled low strength material. After the conduit is installed, random material and crushed aggregate backfill shall be placed along the conduit in layers not to exceed 4 inches (100 mm) compacted. Controlled low strength material shall be placed according to Section [219](#). Any of the types of controlled low strength material may be used. For flexible conduit 60 inches (1 500 mm) through 108 inches (2 700 mm), the backfill material shall be crushed aggregate backfill or controlled low strength material. Unless otherwise specified in the plans, the controlled low strength material can be used as a substitute for random material or crushed aggregate backfill at the contractor's option.

The quality control testing and acceptance of controlled low strength material shall be according to [219](#).

The quality control testing and acceptance for compaction of the random

backfill material shall be in accordance with applicable sections of 207 and 716 and crushed aggregate backfill according to 717, with the following exception:

Testing will be conducted on both sides of the conduit and testing within a lot may include tests on both sides of the conduit. For conduit installations in an embankment where existing tests are on file for the adjacent embankment material, the target percentage of dry density for the conduit backfill will be equal to the average of the X values for the tests in the adjacent lots of embankment material or a minimum value of 95, whichever is greater. For embankments where no tests are on file, the target percentage of dry density will be 95. A lot shall have five (5) density tests performed for quality control.

For conduits less than 60 inches (1500 mm) in diameter, a lot will normally consist of the quantity of backfill required for each 75 linear feet (23 m) of conduit installed.

For conduits 60 inches (1500 mm) in diameter and larger, a lot will normally consist of not more than 5 lifts of backfill. For conduit with lifts of backfill placed for the full length of the conduit, a subplot will normally consist of a lift of backfill placed on both sides for the full length of the conduit. For conduits that are backfilled in segments, a subplot will normally consist of a lift of backfill placed on both sides for the length of each segment of conduit backfilled.

Backfill placed outside embankments and roadbed is to be compacted to or better than the average total dry density for the existing soil. An average total dry density will be determined from representative density tests conducted for each existing soil. Quality control testing will normally consist of one test per 100 linear feet (30 m) of conduit installed and lot evaluations are not required. The moisture tolerance is not applicable.

The use of a bulldozer or other bladed equipment in placing backfill is expressly forbidden. Mechanical equipment with various type buckets may be used. Care shall be taken to compact the material under the haunches of the conduit, to place the backfill evenly on each side of the conduit to retain its vertical axis, and to avoid displacement. This method of backfilling and compacting shall be followed until the top of the trench is reached. In the case of conduit 60 inches (1500 mm) through 108 inches (2700 mm) in diameter, not in trench condition, this backfilling and compacting shall be carried to a height of 2 feet (600 mm) over the top of the conduit and to a width not less than the outside diameter of the conduit plus one diameter on each side. Above this elevation, the embankment shall be placed and compacted in the normal manner. All conduit, after being bedded and backfilled, shall be protected by a four foot (1200 mm) cover of fill, or more if necessary, before heavy equipment is permitted to cross during the construction of the roadway. The Contractor will be held responsible for any damage to the conduit resulting from movement of equipment over the structure.

604.9-FIELD PAVING:

When field paving is required for structural plate pipe and pipe arches, the following provisions shall govern:

The surface to be field paved shall be thoroughly cleaned and dried, and the priming material shall be sufficiently applied with a brush or a mop to coat the surface and to fill all seams or joints. After the priming material has been applied, a wire mesh, having not less than Size # W 1.4 wire and having openings not more than 4 inches (100 mm) by 6 inches (150 mm), shall be placed on top of the corrugations and securely fastened to the bolts with wire or suitable clips.

The reinforcing mesh shall have a width 1 ft. (300 mm) less than the width of the finished paving and shall be fastened to the structure near each edge and at the center of the mesh at points not more than 2 feet (600 mm) apart along the longitudinal barrel of the structure. The paving material shall consist of five parts of clean fine sand, three parts of cement or other fine filler such as limestone dust or lime, and approximately two parts of asphalt cement. The quantity of asphalt may be adjusted to provide a plastic workable mix. Before mixing, the mortar sand shall be dried by heating to approximately 300° F (150° C). After drying, the sand shall be mixed with the fine filler in a steel mortar box or other suitable equipment and heated to 300° F (150° C). The asphalt shall be heated in a separate container to a temperature of 400° F (200° C) and then thoroughly mixed with the sand and filler until a workable mix is obtained. All lumps shall be removed by mixing with a mortar hoe or other suitable implement. The mixture shall be kept hot and shall be applied to the primed surface before cooling. The mixture shall be applied in such a manner that smooth pavement will be formed in the invert, filling the corrugations for at least 25 percent of the circumference of a pipe or 38 percent of the circumference of a pipe arch. The paving thickness shall be sufficient to cover the crests of the corrugations a minimum of 1 in. (25 mm). The placing of the mastic shall be followed closely by the application of a seal coat and hot asphalt cement to be poured uniformly over the paving. The seal coat shall be applied while the paving material is still hot.

The Contractor may pave with portland cement concrete or use shotcrete. If practicable, such paving shall be delayed until completion of the fill over the structure. Before the placing of the paving, the surface of the plates shall be cleaned to the plates or to the asphalt coating if asphalt coated plates are used. When paving with portland cement concrete or shotcrete, mesh reinforcement, fastening of mesh, and paving dimensions shall be as specified for bituminous paving except that the minimum thickness over the crest of the corrugations shall be 1-½ inches (40 mm).

Concrete used shall have a design 28-day compressive strength of 3,000 psi (21 MPa) (equivalent to Class B in 601.3); concrete may be hand mixed and shall be handled and placed as directed by the Engineer. After initial set has taken place, the paving shall be flooded or kept moist by sprinkling for three days. Liquid membrane-forming compound, conforming to 707.9 may be used for curing at a minimum application rate of one gallon per 150 sq. ft. (0.25

liters per m²) of concrete surface. Other methods of curing may be used if approved by the Engineer.

Field paving with shotcrete shall conform to the applicable provisions of 623. When paving with shotcrete, the exposed surface shall be brought to a uniform surface by screeding or troweling. After completion of the shotcrete paving, the rebound material shall be cleaned from the culvert above the paved surface. Shotcrete shall be cured by (a) covering with burlap mats and keeping them wet for at least seven days after placing, (b) flooding for a period of at least seven days or, (c) applying liquid membrane curing compound, conforming to 707.9, at a minimum rate of one gallon per 150 per ft. (0.25 liters per m²) of shotcrete surface for each application. Shotcrete cured by membrane forming compound shall receive two applications; the second application shall be made after the first application has set. Other methods of curing may be used if approved by the Engineer.

After the completion of the fill over the pipe or pipe arch, any gaps which develop between the plates and the concrete or shotcrete paving shall be filled by pouring heated bituminous material complying with requirements of 713.3.

When field paving is specified for metal pipes and metal pipe arches, the methods and materials used shall be the same as specified except that the wire mesh shall be tied to the corrugated metal at points not exceeding 30 inches (750 mm) in any direction and not exceeding 9 inches (225 mm) from the edges of paving. Attachment may be by use of ½" diameter (12 mm) (minimum) commercially-available galvanized or cadmium-plated lag screws twisted firmly into holes drilled in the valleys of the corrugations or by other approved means.

Prior to using portland cement concrete or shotcrete for paving aluminum alloy culverts or culverts with coatings containing aluminum, the aluminum-concrete contact area shall be coated with commercially-available paint.

604.10-RELAID CONDUIT:

The construction requirements in this Section shall apply equally in the case of relaid conduits. All conduits salvaged for relaying shall be cleaned of all foreign material prior to reinstallation.

604.11-JACKING CONDUIT:

Jacking or tunneling may be designated on the Plans or may be permitted if written approval is obtained. Conduit to be jacked may be either reinforced concrete or corrugated steel, as called for in the Plans. The strength of conduit designated in the Contract will be designated as required for vertical load only.

Additional reinforcement or strength of conduit required to withstand jacking pressure shall be determined and furnished by the Contractor without additional cost to the Division. Variation from theoretical alignment and grade at the time of completion of jacking placement shall not exceed 0.2 ft. for each 20 ft. (10 mm per m) of conduit so placed. Corrugated steel pipe section to be jacked shall be prepared for making field joints either by riveting or bolting. Concrete pipe to be jacked shall be tongue and groove type.

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An approach trench shall be constructed on the side from which jacking operations shall take place. The end of the approach trench away from the jacking face shall be cut perpendicular to the axis of the jacking operation to provide bearing surface for the back stop and the jack blocking. The length of the approach trench shall be such that the distance between the jack blocking and the face of the bore shall be equal to 5 feet (1500 mm) plus the length of the individual pipe sections in the case of corrugated steel pipe. When concrete pipe is jacked, the maximum length of the approach trench shall be equal to two lengths of pipe plus a minimum of 7 feet (2.1 m) for jack and blocking. The jacking face shall be a minimum of 3 feet (1 m) above the top of the pipe; the face shall be cut vertically and shall be shored to prevent raveling and slipping. A sump shall be constructed in one corner of the trench to provide drainage. In the case of corrugated steel pipe, a transverse trench shall be constructed at the jacking face to provide clearance for the riveting and bolting of joints. The back stop shall be constructed of heavy timbers or steel rails capable of withstanding the jacking force.

In the event the site of jacking operations is such that an approach trench cannot be constructed, the jack blocking shall be constructed to carry the reaction of the jack to the ground. This may be accomplished by means of timber, steel, or concrete vertical back stops set into the ground with the tops supported by diagonal members bearing against an embedded anchorage.

Directly opposite the approach trench, an exit trench shall be constructed to line and grade. The exit trench shall be constructed in the same manner as the approach trench except that no back wall is necessary.

Jacks shall be of sufficient capacity to overcome soil resistance to the jacking operation and shall be operated in pairs. As a guide, capacity of jacks for corrugated steel pipe shall be a minimum of 35 tons (32 Mg) each and for concrete pipe a minimum of 50 tons (45 Mg) each. For large pipe, more than one pair of jacks may be required. Small track jacks may be used to start the pipe.

Pipe guides shall be constructed in the approach trench and may be either timber or steel rail or concrete guides on a cradle. Since the pipe guides will support the pipe as it enters the jacking face, the pipe guides shall be accurately set to line and grade, and excavation for the guides shall be made to grade to avoid occurrence of settlement. Guides shall be spaced at $\frac{1}{2}$ the pipediameter inside face to inside face of the guides for corrugated steel pipe and at $\frac{4}{10}$ the outside diameter for concrete pipe.

Reaction of the jack to the pipe shall be transmitted by either a jacking frame or jacking beams constructed of timber or steel. Jacking frames and beams shall be so placed as to exert equal pressure on each side of the pipe. For pipes 36 inches (900 mm) in diameter or smaller, a steel jacking ring may be used in lieu of the jacking frame.

The pressure from the jacking frame or beams may be transmitted to a jacking collar or head on the pipe itself. In the case of corrugated steel pipe, a jacking band reinforcing the end of the pipe receiving the thrust shall be used. Jacking collars or heads for concrete pipe shall be constructed to prevent

damage to the pipe ends. Jacking collars and jacking frames shall be constructed to allow passage of men and material.

Joints of concrete pipe shall be cushioned and protected from infiltration of fine materials occurring during the jacking operation by insertion of a cushioning material into each pipe joint. After the pipe is in position, the joints shall be pointed from the inside with mortar joint compound.

Steel cutting edges on the lead section of pipe may be used, and the use of a jacking shield is permitted.

To prevent the pipe from "freezing" and becoming incapable of movement, jacking operations should, if possible, be carried out on a 24-hour basis. A minimum of two 8-hour shifts shall be worked. Alignment and grade of the pipe guides shall be checked at least once each shift. To aid in the prevention of "freezing," the pipe may be lubricated in a manner and with a material meeting the approval of the Engineer.

Excavation for the bore shall be to grade at the bottom and approximately 1 in. (25 mm) greater than the diameter of the pipe at the top and sides. Initial jacking of concrete pipe shall begin with two sections of pipe in the trench. As excavation proceeds, the jacking shall proceed until the effective limit of the jacking is reached, at which time additional blocking shall be added. This process shall be continued until there is room for an additional pipe section. For long runs of pipe, the use of intermediate jacking stations will be allowed as approved by the Engineer.

Pipe cover shall be a minimum of one diameter or 3 feet (900 mm) from top of pipe to bottom of the subgrade of ballast when jacking under a bituminous concrete highway. When jacking under reinforced concrete pavement, the cover may be reduced to the depth of the base course plus the pavement thickness with a minimum cover of the pavement thickness plus 6 inches (150 mm).

After the pipe has been jacked into place, the backfill shall be tightly compacted around both ends of the culvert to prevent erosion. Any departure from the above specifications necessitated due to site conditions shall be approved in writing by the Engineer.

Areas resulting from caving or excavation outside the above limits shall be backfilled with sand or grout by a method which will fill the voids. Joints shall be completed as specified for the type of conduit being installed.

604.12-METHOD OF MEASUREMENT:

Conduit of the different types and sizes, both new and relaid, will be measured by the linear foot (m) in place, the measurement being made along the centerline of each pipe installed. Branch connections, tees, wyes, and elbows will be measured along their centerlines and these lengths included in the total lengths of the appropriate conduit. Wyes, tees, and other branch connections will be measured along the centerlines to points of intersection. Conduit with sloped or skewed ends will be measured along the invert. The portion of pipe extending through to the inside face of headwalls of all types, manholes, inlets, boxes, or other structures shall be included in the measurement.

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End sections will be measured by the number of units installed.

Conduit designated on the Plans to be installed by the jacking method will be measured separately by the linear foot (m) in place and shall be the actual portion jacked, completed in place, and accepted.

604.13-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed in 604.14, which prices and payments shall be full compensation for excavation and bedding, except as otherwise provided, backfilling, jacking when called for, furnishing all materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work. The unit price bid for end sections shall include excavation and backfill.

When, by the authority of the Engineer, the flow line of a conduit is lowered from that shown on Plans, or due to a lack of a firm foundation, or due to a solid rock foundation, unsatisfactory material is removed and replaced with suitable material, the work of excavation, replacement, and compaction of material will be paid for in accordance with 109.4.

- i. For conduits less than 48-in. (1200 mm) diameter, the work of excavation, measured in excess of 1 ft. (300 mm) below the original planned conduit elevation, will be paid for under the provisions of 109.4. When suitable material is not available from the project excavation, payment for replacement material below final grade line will be made in accordance with 109.4.
- ii. For conduits 48-in. (1200 mm) diameter or larger, all additional excavation below the original planned conduit elevation and for a width not in excess of the outside conduit diameter plus 18 inches (450 mm) on each side of the conduit, will be paid for at the unit bid price for Item 207001-* "UNCLASSIFIED EXCAVATION". When no Item 207001-* is included in the Proposal, payment for excavation, backfill compaction and replacement material will be made in accordance with 109.4. When suitable material is not available from the project excavation, replacement material will be paid for in accordance with 109.4.

604.14-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
604001-*	"size" METALLIC COATED CORRUGATED STEEL PIPE, YZ	LINEAR FOOT (METER)
604002-*	"size" FULL BITUMINOUS COATED CORRUGATED STEEL PIPE, YZ	LINEAR FOOT (METER)
604003-*	"size" HALF BITUMINOUS COATED AND PAVED INVERT CORRUGATED STEEL PIPE, YZ	LINEAR FOOT (METER)
604004-*	"size" FULL BITUMINOUS COATED AND PAVED INVERT CORRUGATED STEEL PIPE, YZ	LINEAR FOOT (METER)
604005-*	"size" FULL BITUMINOUS COATED AND FULL PAVED CORRUGATED STEEL PIPE, YZ	LINEAR FOOT (METER)

604006-*	"size" FIBER BONDED FULL BITUMINOUS COATED CORRUGATED STEEL PIPE, YZ	LINEAR FOOT (METER)
604007-*	"size" HALF BITUMINOUS COATED CORRUGATED STEEL PIPE ARCH, YZ	LINEAR FOOT (METER)
604008-*	"size" FIBER BONDED FULL BITUMINOUS COATED AND FULL PAVED CORRUGATED STEEL SEWER PIPE, YZ	LINEAR FOOT (METER)
604009-*	"size" CORRUGATED STEEL PIPE END SECTION, YZ	EACH
604010-*	"size" METALLIC COATED CORRUGATED STEEL PIPE ARCH, YZ	LINEAR FOOT (METER)
604011-*	"size" FULL BITUMINOUS COATED CORRUGATED STEEL PIPE ARCH, YZ	LINEAR FOOT (METER)
604012-*	"size" HALF BITUMINOUS COATED AND PAVED INVERT CORRUGATED STEEL PIPE ARCH, YZ	LINEAR FOOT (METER)
604013-*	"size" FULL BITUMINOUS COATED AND PAVED INVERT CORRUGATED STEEL PIPE ARCH, YZ	LINEAR FOOT (METER)
604014-*	"size" FIBER BONDED FULL BITUMINOUS COATED CORRUGATED STEEL PIPE ARCH, YZ	LINEAR FOOT (METER)
604015-*	"size" FIBER BONDED FULL BITUMINOUS COATED AND PAVED INVERT CORRUGATED STEEL PIPE ARCH, YZ	LINEAR FOOT (METER)
604016-*	"size" CORRUGATED METAL PIPE ARCH END SECTION,	EACH
604017-*	"size" STRUCTURAL PLATE PIPE, YZ	LINEAR FOOT (METER)
604018-*	"size" FULL BITUMINOUS COATED STRUCTURAL PLATE PIPE, YZ	LINEAR FOOT (METER)
604019-*	"size" FULL BITUMINOUS COATED AND FIELD PAVED STRUCTURAL PLATE PIPE, YZ	LINEAR FOOT (METER)
604020-*	"size" STRUCTURAL PLATE PIPE ARCH, YZ	LINEAR FOOT (METER)
604024-*	"size" FULL BITUMINOUS COATED STRUCTURAL PLATE ARCH, YZ	LINEAR FOOT (METER)
604025-*	"size" CORRUGATED ALUMINUM ALLOY PIPE, YZ	LINEAR FOOT (METER)
604026-*	"size" CORRUGATED ALUMINUM ALLOY PIPE, FIELD PAVED, YZ	LINEAR FOOT (METER)
604027-*	"size" HALF BITUMINOUS COATED AND PAVED INVERT CORRUGATED ALUMINUM ALLOY PIPE, YZ	LINEAR FOOT (METER)
604028-*	"size" CORRUGATED ALUMINUM ALLOY PIPE END SECTION,	EACH
604029-*	"size" CORRUGATED ALUMINUM ALLOY PIPE ARCH, YZ	LINEAR FOOT (METER)
604032-*	"size" CORRUGATED ALUMINUM ALLOY PIPE ARCH END SECTION,	EACH
604033-*	"size" ALUMINUM ALLOY STRUCTURAL PLATE PIPE, YZ	LINEAR FOOT (METER)
604034-*	"size" ALUMINUM ALLOY STRUCTURAL PLATE PIPE ARCH, YZ	LINEAR FOOT (METER)
604036-*	"size" NONREINFORCED CONCRETE SEWER PIPE , CLASS **	LINEAR FOOT (METER)
604037-*	"size" REINFORCED CONCRETE PIPE, CLASS **	LINEAR FOOT (METER)
604038-*	"size" REINFORCED CONCRETE PIPE END SECTION	EACH
604039-*	"size" REINFORCED CONCRETE PIPE ARCH, CLASS **	LINEAR FOOT (METER)
604040-*	"size" REINFORCED CONCRETE PIPE ARCH END SECTION	EACH

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604041-*	"size" REINFORCED CONCRETE ELLIPTICAL PIPE, Y	LINEAR FOOT (METER)
604043-*	"size" CLAY LINED REINFORCED CONCRETE PIPE, CLASS **	LINEAR FOOT (METER)
604045-*	"size" CLAY PIPE, EXTRA STRENGTH,	LINEAR FOOT (METER)
604050-*	"size" CORRUGATED POLYETHYLENE PIPE,	LINEAR FOOT (METER)
604052-*	"size" POLYVINYLCHLORIDE PIPE	LINEAR FOOT (METER)
604053-*	"size" RELAID CONDUIT	LINEAR FOOT (METER)
604054-*	"size" JACKED CONDUIT, REINFORCED CONCRETE PIPE, CLASS **	LINEAR FOOT (METER)
604057-*	"size" PRECOATED GALVANIZED STEEL PIPE,	LINEAR FOOT (METER)
604062-*	"size" METALLIC COATED CORRUGATED STEEL PIPE, FIELD PAVED, YZ	LINEAR FOOT (METER)
604065-*	"size" STRUCTURAL PLATE PIPE ARCH, FIELD PAVED, YZ	LINEAR FOOT (METER)
604070-*	"size" PRECAST CONCRETE BOX CULVERT,	LINEAR FOOT (METER)
604071-*	"size" REINFORCED CONCRETE PIPE SAFETY SLOPE END SECTION, CLASS	EACH
604072-*	"size" CORRUGATED STEEL PIPE SAFETY SLOPE END SECTION, YZ	EACH
604073-*	"size" ELLIPTICAL REINFORCED CONCRETE PIPE SAFETY SLOPE END SECTION, Y	EACH
604074-*	"size" ALUMINUM BOX CULVERT, YZ	LINEAR FOOT (METER)
604075-*	"size" FIELD PAVED ALUMINUM BOX CULVERT, YZ	LINEAR FOOT (METER)
604076-*	"size" ALUMINUM COATED CORRUGATED STEEL PIPE, YZ	LINEAR FOOT (METER)
604077-*	"size", ALUMINUM COATED CORRUGATED STEEL PIPE ARCH, YZ	LINEAR FOOT (METER)
604078-*	"size", HALF BITUMINOUS COATED CORRUGATED STEEL PIPE, YZ	LINEAR FOOT (METER)
604079-*	"size" HALF BITUMINOUS COATED CORRUGATED STEEL PIPE ARCH, YZ	LINEAR FOOT (METER)
604080-*	604080-* "size" ALUMINUM COATED CORRUGATED STEEL PIPE HALF BITUMINOUS COATED AND PAVED INVERT	LINEAR FOOT (METER)
604081-*	"size" STEEL BOX CULVERT	LINEAR FOOT (METER)

* Sequence Number

** Class designated by Roman numerals

*** Base Metal Thickness in inches (mm)

Note: For Aluminum Box Culverts, haunch and crown plate thicknesses as specified on the Plans.

Note:

X = a two digit number which defines the item.

Y = a letter, if present, designating base metal thickness or type of elliptical concrete pipe in accordance with the table below.

Z = a 1 digit number designating metal pipe corrugations or Roman

numerals designating concrete pipe class or a 1 digit number designating elliptical concrete pipe class in accordance with the table below.

	Mil Thickness	
Y	Steel	Aluminum
A	64 (1.63)	60 (1.52 mm)
B	79 (2.0)	75 (1.90 mm)
C	109 (2.77)	105 (2.67 mm)
D	138 (3.51)	135 (3.43 mm)
E	168 (4.27)	164
F	188 (4.78)	---
G	218 (5.54)	---
H	249 (6.32)	---
J	280 (7.11)	--
K	---	100 (2.54 mm)
L	---	125 (3.18 mm)
M	---	150 (3.81 mm)
N	---	185 (4.41 mm)
P	---	200 (5.08 mm)
Q	---	225 (5.72 mm)
R	---	250 (6.35 mm)

Z	Metal Corrugations	Pipe Class
1	1½" x ¼" (37.5 x 6.25 mm)	---
2	2⅔" x ½" (66.8 x 12.5 mm)	---
3	3" x 1" (75 x 25 mm)	---
5	5" x 1" (125 x 25 mm)	---
6	6" x 2" (150 x 50 mm)	---
7	7½" x ¾" x ¾" (190 x 19x 19)	---
I or 1	---	I
II or 2	---	II
III or 3	---	III
IV or 4	---	IV
V or 5	---	V
Y	Concrete Pipe	
H	Horizontal Elliptical	
V	Vertical Elliptical	